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# Assessment of City Environmental Quality in Western China Based on Matter Element Extension—a Case Study Of Chongqing

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## Abstract

Through the empirical analysis of Chongqing environmental quality , it is found that the indicator system we built can reflect a city's environment quality systematically and completely, and the assessment results were consistent with the fact. The environmental quality level of Chongqing in 2001 and 2002 are III, from year 2003-2008 are level I , and the improvement degree increased year by year. In addition, the environment quality correlation with level III and level IV decreased year by year, correlation with level I grew overall with slight rebounding in some years and the level 2 changed fluctuant. The results show investment in environmental protection and environmental quality level has a strong correlation between changes, it indicates that environmental protection investment plays an important role for the improvement of city environmental quality.

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## 1. Introduction

Environmental quality was rich in content; it includes the water environment, atmospheric environment, solid waste, industrial waste, etc., and usually associated with demographic, economic, social and other aspects of resources, so the environment is a quite complex systematic problem. In practice, the studies found that the assessment results of each single index of environmental quality

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system have the characteristics of incompatibility, so it's difficult for traditional assessment methods to solve such problem. Fussy Math is a common methods to solve the problems with meaning clear and extension is not clear[1-2], but it is an idealistic methods with facing data of space form [3].The matter element extension overcome the disadvantages of fussy math, it's an unique methodology of research and conflict resolution methods based on matter-element and extension set theory. In solving problems, it can be directly used for the problems and make use of the concepts and relationships of matter-element, conditional matter element, the object concepts of matter-element, given a formal model and quantitative analysis methods for incompatible problem with matter-element extension set and correlation function [4-5]. Chongqing is the unique municipality in western China, economic centre of Yangtze River, important economic growth pole in western China and supporting reform pilot area of the national urban and rural coordinated development, its development model has a positive reference for other western regions. As an important part of "Cheng-Yu Economy Region", Chongqing act roles of bridge head of "Western Development" even combining the middle and western China. In addition, Chongqing locates in Yangtze River, rich in water resource, so the development path of Chongqing has some inspiration to other city of Yangtze River. With the development of time, sustainable development has been growing attention day by day, the environmental problem becomes more and more seriously. How to accomplish the sustainable development between economy and environment is become a focus for almost all regional governments and decision makers.

## 2. Matter Element Extension Theory

For any element  $a$ , if it has propositions as following:  $a$  has property  $p$ ;  $a$  not has property  $p$ ;  $a$  either has property or not has property  $p$ ; makes the original element not has property  $p$  change into has property  $p$ . We defined the set as an extension set if there has at least one of four propositions above established. Extension-set measure the relationships between element and set through the number of correlation. It makes quantitative incompatibility solution into possible with using algebraic to represent the correlation function. Because the uniqueness of matter element extension, it has applied in disaster assessment and forecasting, evaluation of resources, environment and other products. [6-9].

### 2.1. matter element matrix

It often expressed the thing  $M$  which has character  $C$  and quantity  $X$  as:

$$R = (M, C, X) \quad (1)$$

### 2.2. Interval module

In common it defines the module of bounded interval  $x = [a, b]$  as:  $|x| = |b - a|$

### 2.3. Distance between points and interval

It defines the distance between any points  $x_0$  to interval  $x = [a, b]$  as:

$$\rho(x_0, x) = \left| x_0 - \frac{(a+b)}{2} \right| - \frac{b-a}{2} \quad (2)$$

## 2.4. Correlation function

In assessment of matter-element, when the quantity of matter-element expressed by correlation function as a real axis point, range degree of matter-element meet the requirement, it makes the result of incompatible problem solution quantitative. If the interval  $x_0 = [a, b]$ ,  $x_1 = [c, d]$ , the correlation function  $k(x)$  defines as:

$$k(x) = \begin{cases} -\frac{\rho(x_0, x)}{|x_0|} & x \in x_0 \\ \frac{\rho(x_0, x)}{\rho(x_0, x_{pi}) - \rho(x_0, x)} & x \notin x_0 \end{cases} \quad (3)$$

## 3. Empirical analysis

Because of the complexity of environmental system, consider the reality of Chongqing, to the principle of integrity of system, data availability, science and rationality, built the assessment system and level standard as table 1.

Table 1 Level of standards of environmental quality evaluation system

No.	indicator	unit	Level of indicators				Range of section field	
			I	II	III	IV	min	max
x1	Green coverage	%	45	35	25	15	0	50
x2	Daily average of TSP	(mg/m <sup>3</sup> )	0.087	0.13	0.15	0.2	0	0.3
x3	Daily average of SO <sub>2</sub>	(mg/m <sup>3</sup> )	0.02	0.06	0.1	0.2	0	0.3
x4	Daily average of NO <sub>2</sub>	(mg/m <sup>3</sup> )	0.05	0.1	0.15	0.2	0	0.3
x5	Compliance rate of water	%	100	85	70	55	0	100
x6	Rate of sewage treatment	%	100	85	70	55	0	100
x7	Compliance rate of industry water discharge	%	100	90	80	70	0	100
x8	Utilization rate of Industrial Solid Wastes	%	100	90	80	70	0	100
x9	Average Noises in Downtown	dB(A)	50	60	70	80	0	100
x10	Compliance rate of industry SO <sub>2</sub> discharge	%	85	70	55	40	0	100
x11	Compliance rate of industry Soot discharge	%	95	85	75	65	0	100
x12	Compliance rate of industry Dusts discharge	%	95	85	75	65	0	100
x13	Investment index of environment protection	%	3	2.5	2	1.5	0	10

When we establish the classical field matter-element matrix, consider the Daily average of TSP, Daily average of SO<sub>2</sub>, Daily average of NO<sub>2</sub> and Average Noises in Downtown show trends of opposite direction changing, so it is need to establish the matter-element matrix after convert the indicators into the same direction. According to the formula (1), (2) and (3) to calculate the correlation value of each indicator and then calculate the normalized weights with formula as below:

$$w_{ij} = \frac{x_i}{x_{ij}} \bigg/ \sum_{i=1}^n \frac{x_i}{x_{ij}} \quad (4)$$

According to the calculation results, we can get the comprehensive correlation degree of each level with summarize the number of each correlation value multiply corresponding weights, the formula is:

$$a_j = \sum_{i=1}^{13} w_{ij} \bullet k_j(x_i) \quad (5)$$

Make use of the formula (5) to calculate comprehensive correlation degree of each level, for example, as a case study of 2001, the result is level I = -0.1790; level II = -0.2223; level III = -0.1553; level IV = -0.3016; the results show the maximum number is level III, so the assessment result of Chongqing environmental quality in 2001 is level III. According to the calculation principle above, use the actual value from 2001-2008 to calculate the results of each year's comprehensive correlation value is shown in table2.

Table2 Results of comprehensive correlation value from 2001-2008

Level	2001	2002	2003	2004	2005	2006	2007	2008
level I	-0.1790	-0.2035	-0.1841	-0.1450	-0.0713	0.0332	0.0640	0.0770
level II	-0.2223	-0.2027	-0.1844	-0.2135	-0.2785	-0.3515	-0.2453	-0.3263
level III	-0.1553	-0.1920	-0.2198	-0.2183	-0.3358	-0.3901	-0.3700	-0.4846
level IV	-0.3016	-0.3088	-0.3286	-0.3752	-0.4200	-0.4516	-0.4521	-0.5328

#### 4. Conclusion

Through the empirical analysis of Chongqing environmental quality, it is found that the indicator system we built can reflect a city's environment quality systematically and completely, the environmental quality of Chongqing is level III in 2001 and 2002, is level I from 2003-2008, and the improvement degree shows increased year by year. In addition, according to the table 2, the value of level from 2001-2005 are negative, from 2006-2008 are positive. The assessment results are consistent with the fact.

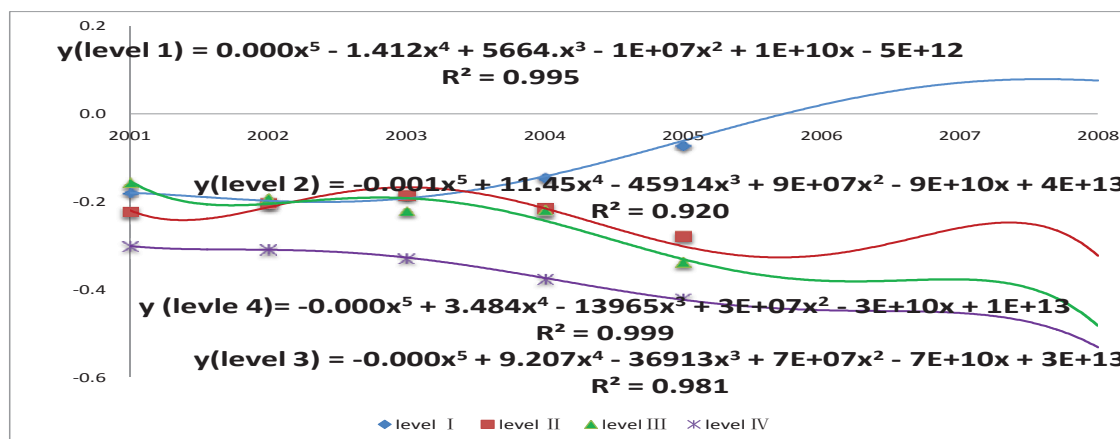


Fig 1 Results of curve fitting

According to table 2, the environmental system correlation with level III and IV shows a declining trend yearly, it means Chongqing environmental quality moved from level III and IV to level II and I. In addition, although the correlation with level I has some fluctuations, the overall trend is increased. The level III shows undulating changes. It means the level of Chongqing environmental quality is at the critical point between level I and II although the result is level I. Through the investment index of environmental protection from table 1, it shows the index has fluctuation, but the money spend on

investment increased yearly, so it can be sure that increasing the investment is an important methods for a city to improve the environmental quality. In addition, use the investment as argument, use the correlation value of each level as depend variable to fit the curve, the result is shown in fig 1. The practice shows matter-element extension has advantages of easy to use, strong quantitative specification on solving problem of complex systems assessment with single index incompatible. The results have good operability on horizontal and vertical comparisons.

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